AN ALTERNATIVE FORM OF POTENTIAL VORTICITY

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[Central Meteorological Observatory, Tokyo, June 1941]

Potential vorticity ζ_0 is defined by C. G. Rossby [1] as the vorticity which a column of air between two isentropic surfaces would have if it were brought to an arbitrary "standard" latitude and then stretched or shrunk to an arbitrary "standard" thickness. If f is the Coriolis parameter $2\omega \sin \varphi$ at a given latitude φ, and ζ the actual vorticity of an air column of thickness D at its observed position, then from Rossby's vorticity theorem we have

$$\frac{f+\zeta}{D}=\frac{f_0+\zeta_0}{D_0}, \tag{1}$$

where ζ_0 is the vorticity which the air column would have if brought to a latitude where the Coriolis parameter has the value f_0, and to a thickness D_0. If f_0 and D_0 are the adopted standards of comparison, ζ_0 is the potential vorticity, a term chosen by analogy with potential temperature.

In a previous paper [2] the present author has presented results of an investigation in which a newly-defined type of potential temperature was employed. In that paper a potential vorticity of air *particles*, not of air *columns*, was introduced; it is defined as the vorticity which a particle of air would have if it were brought to an arbitrary "standard" latitude and to an arbitrary "standard" density. The author has shown that if ρ is the density,

$$\frac{f+\zeta}{\rho}=\frac{f_0+\zeta_0}{\rho_0}, \tag{2}$$

where ζ_0 is the potential vorticity which an air particle would have if brought to a standard latitude, and to a standard density ρ_0. This type of potential vorticity as a conservative element for identification purposes seems to be better than that of Rossby, because the analysis does not involve the concept of a column of air.

To apply this quantity to isentropic analysis, assuming isentropic flow, equation (2) may be written

$$\frac{f+\zeta}{p^{c_v/c_p}}=\frac{f_0+\zeta_0}{p_0{}^{c_v/c_p}}, \tag{3}$$

where c_p and c_v are the specific heat at constant pressure and the specific heat at constant volume, respectively. Thus f_0 and p_0 are the arbitrary standards on an isentropic surface to which all particles are brought for comparison and ζ_0 is the potential vorticity.

In view of the significance of Rossby's potential vorticity [3], the recognition of a simpler form is of fundamental importance in meteorology.

[1] C. G. Rossby: Planetary Flow Patterns in the Atmosphere, *Quarterly Journal of the Royal Meteorological Society, 66*, Supplement, 1940, p. 72.

[2] H. Arakawa: Die Wirbelgleichungen mit Berücksichtigung der Erddrehung, *Meteorol. Zeitschr.*, 1941, Heft 2. Herein a slight misprint occurred; in example 2 and example 4, change "$\frac{\partial u}{\partial x}$ and $\frac{\partial v}{\partial y}$" to "$\frac{\partial w}{\partial x}$ and $\frac{\partial w}{\partial y}$".

[3] V. P. Starr and M. Neiburger: Potential Vorticity as a Conservative Property, *Journal of Marine Research*, Vol. III, No. 3, 1940; M. Neiburger: Vorticity Analysis of a Thunderstorm Situation, *Bull. Amer. Metl. Soc., 22*, 1, 1941.

METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR JULY 1941

[Climate and Crop Weather Division, J. B. KINCER in charge]

AEROLOGICAL OBSERVATIONS

By EARL C. THOM

The mean surface temperatures for July were above normal over most of the country. Temperatures were slightly below normal, however, in a considerable part of the Southern Plateau region and at four scattered stations in the eastern half of the country. At all stations in other sections of the country temperatures were above normal, with values considerably above normal over the north-central and the northwestern areas, departures for the month being from +6° to +8° F. over parts of Washington and Oregon.

At 1,500 meters above sea level the 5 a. m. resultant winds for July were from directions to the north of normal over the extreme northeast, the upper Gulf region, and over parts of the central and northwestern sections, and from south of normal at this level over the rest of the country. At 3,000 meters the morning resultant winds for July were more northerly than normal over most of the northeast, over a considerable part of the Western Plains States, and over a strip of the Rocky Mountains along the Great Divide, and were more southerly than normal elsewhere. When the 5 p. m. resultant winds for the month at the 5,000 meter level are compared with the corresponding 5 a. m. normals it is noted that the late afternoon resultants were more southerly than the corresponding morning winds at about two-thirds of the stations for which these data could be compared.

At both the 1,500 m. and 3,000 m. levels the resultant velocities were below normal over most stations, being above normal over only eight pilot-balloon stations at each of these levels. At 5,000 meters, however, the 5. p. m. resultant velocities were generally higher than the corresponding 5 a. m. normals.

At 1,500 meters the 5 p. m. resultant winds were from more northerly directions than were the corresponding 5 a. m. winds over most of the Rocky Mountain and Plateau regions and over a considerable part of the Mississippi River Valley and the Gulf coast, while a turning to the southward during the day was noted at this level over the rest of the country. At 3,000 meters the resultants turned to the northward during the day over a considerable portion of the country. The opposite shift during the day was noted at this level over most stations along the Atlantic Coast, over the northern Plateau and Great Plains regions, and over two stations to the southward.

The 5 p. m. resultant velocities for the month were higher than the corresponding 5 a. m. velocities over the extreme west and over part of the extreme southeast and were lower at this level over most of other pilot-balloon stations of the country. At 3,000 meters the resultant velocities in the late evening were lower than those in the early morning over 10 widely scattered stations. An increase in resultant velocity occurred during the day at this level over all other stations.

The upper-air data discussed above are based on 5 a. m. (eastern standard time) pilot-balloon observations (charts VIII & IX) as well as on observations made at 5 p. m. (table 2 and charts X and XI).

Radiosonde and airplane stations located in the southern